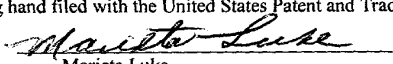
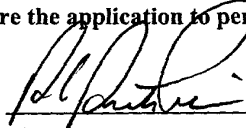


FORM PTO-1390 OFFICE (REV 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK		ATTORNEY'S DOCKET NUMBER 358362010400	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. § 371				U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/889508	
INTERNATIONAL APPLICATION NO. PCT/JP00/00137		INTERNATIONAL FILING DATE JUL 18 2001 18 January 2000		PRIORITY DATE CLAIMED 19 January 1999	
TITLE OF INVENTION FLAME-RETARDANT POLYESTER FIBER, WOVEN OR KNITTED FLAME-RETARDANT POLYESTER FIBER FABRIC, NONWOVEN FLAME-RETARDANT POLYESTER FIBER FABRIC AND WOVEN OR KNITTED SUEDE FABRIC					
APPLICANT(S) FOR DO/EO/US Masao MATSUDA et al.					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input checked="" type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). <input type="checkbox"/> An English language translation of the International Application under PCT Article 19 (35 U.S.C. 371(c)(2)). a. <input type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)). a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). Items 11. to 16. below concern document(s) or information included: 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input type="checkbox"/> A FIRST preliminary amendment. 14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 15. <input type="checkbox"/> A substitute specification. 16. <input type="checkbox"/> A change of power of attorney and/or address letter. 17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825. 18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 20. <input checked="" type="checkbox"/> Other items or information: International Search Report; PCT Request; Notification of Receipt of Record Copy; Notification Concerning Submission or Transmittal of Priority Document; Notice informing the Applicant of the Communication of the International Application to the Designated Offices; return receipt postcard.					
CERTIFICATE OF HAND DELIVERY I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on July 18, 2001.  Marieta Luke					

U.S. APPLICATION NO. (if known, see 37 CFR 1.51 to be assigned) 09/889508		INTERNATIONAL APPLICATION NO. PCT/JP00/00137		ATTORNEY'S DOCKET NUMBER: 358362010400	
21. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.....\$1,000.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO.....\$860.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....\$710.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provision of PCT Article 33(1)-(4)\$690.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)\$100.00				CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$860.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$0.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	11 - 20 =	0	x \$18.00	\$0.00	
Independent claims	1 - 3 =	0	x \$80.00	\$0.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$860.00	
Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$0.00	
SUBTOTAL =				\$860.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				+	\$0.00
TOTAL NATIONAL FEE =				\$860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				+	\$0.00
TOTAL FEES ENCLOSED =				\$860.00	
				Amount to be refunded:	\$
				charged:	\$
a. <input checked="" type="checkbox"/> Please charge my <u>Deposit Account No. 03-1952</u> in the amount of \$860.00 to cover the above fees. A duplicate copy of this sheet is enclosed. b. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees that may be required, or credit any overpayment to <u>Deposit Account No. 03-1952</u> .					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
Barry E. Bretschneider Morrison & Foerster LLP 2000 Pennsylvania Avenue, N.W. Washington, D.C. 20006-1888			 SIGNATURE Barry E. Bretschneider Registration No. 28,055		

SPECIFICATION

FLAME-RETARDANT POLYESTER FIBER, WOVEN OR KNITTED FLAME-RETARDANT POLYESTER FIBER FABRIC, NONWOVEN FLAME-RETARDANT POLYESTER FIBER FABRIC AND WOVEN OR KNITTED SUEDE FABRIC

5

Technical Field

The present invention relates to a flame-retardant polyester fiber, which is superior in dyeing property, color fastness to light, abrasion resistance and heat stability, and which also has fine whiteness, and to a cloth and raised woven, 10 knitted fabric made by the use of this fiber.

Background Art

Because polyester fibers are easy to handle and economically advantageous as compared to other synthetic fibers, they are applied to an extremely broad range of use. On the 15 other had, they are inferior to natural fiber in feeling, function and the like, because they have a dense molecule structure, are hydrophobic and have a uniform fiber surface. As regards dyeing property, polyester requires dyeing under high temperature and high pressure conditions, for, otherwise, the 20 dye cannot enter the molecules and cannot dye polyester to a sufficient color density, which is a defective aspect.

As a recent tendency, novel polyester fibers having various functions (e.g., water absorption, moisture absorption, generation of heat, heat storage, flame retardancy and the like), 25 have been increasingly developed to cope with the diversification of the needs of the consumers, and a great variety of functional fibers have been developed. A fiber product having flame retardancy is, among such polyester fibers, drawing increasing attention whether generally or publicly, as 30 necessitated by the rise in consciousness toward protection against disasters, strengthening of flame retardancy regulations associated with the preparation of the law and the like. In particular, a number of polyester products are used for interior-related products for hotels, inns, hospitals, welfare 35 institutions and the like, and these products are indispensably

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required to have flame retardancy. The demand for fiber products having flame retardancy has been expanding markedly at home as well as abroad, and is expected to expand furthermore in the future.

5 However, conventional flame-retardant products have many problems in that harmful gas is generated on incineration, such as cyanide, halogen and the like, the feeling of the product is rough and hard, since a flame-retardant agent is applied to the fiber surface in a post-processing treatment, the flame
10 retardancy of the product lacks resistance to washing, and the like.

 In an attempt to solve such defects, one method proposes copolymerization with a phosphorus compound to introduce phosphorus atom (one of the atoms that impart flame retardancy)
15 into the molecular main chain (main chain type, JP-B-36-21050, JP-B-38-9447, JP-B-53-13479, JP-A-50-53354). These main chain type methods are all associated with problems of poor resistance to hydrolysis due to the presence of phosphorus atom in the polyester main chain, degraded dyeing property due to high
20 crystallinity, poor feeling when processed into a cloth, and the like.

 There is also known a flame-retardant copolymerized polyester fiber (side chain type) wherein a phosphorus atom is introduced into the side chain of polyester molecule (JP-B-60-
25 38417 and the like). The side chain type phosphorus copolymerized polyester fiber is superior in dyeing property as compared to the main chain type, but is not sufficient. When the dyeing property of a side chain type phosphorus copolymerized polyester fiber is improved, abrasion resistance
30 and heat stability tend to fall. A flame-retardant polyester fiber superior in dyeing property and mechanical property, such as abrasion resistance, heat stability and the like, has not been obtained as yet.

 In addition, the above-mentioned phosphorus copolymerized
35 polyester is associated with problems of decreased

polymerization rate due to the phosphorus compound, darkening and degraded spinning operability due to the reduced amount of antimony catalyst, and poor color tone due to the yellowness of monomer itself.

5 Thus, JP-A-6-16796 proposes a method of improving polymerization rate and color tone of polymer by combining a specific condensation polymerization catalyst. This method can improve polymerization rate but the use of a titanium catalyst results in degraded heat stability of the polymer and increased
10 coloring thereof in yellow, particularly after spinning. As a result, the color tone of the polymer can be improved to a certain degree but not enough to increase its whiteness, which makes this polymer inapplicable to a use requesting high whiteness.

15 In the case of the aforementioned main chain type phosphorus copolymerized polyester, it shows poor resistance to hydrolysis and decreased tenacity of fiber in a subsequent step because phosphorus atom is incorporated in the polymer main chain.

20 The polyester raised warp knitted fabric has been widely used for clothing, car seat, chair cover, coverlet used over a kotatsu and the like. As the situation stands now, however, raised warp knitted fabric made of a polyester fiber has markedly low flame retardancy because of the steps applied for
25 raising, dyeing and antistatic processing, to the point that the flame retardancy standard set for each use can be hardly met. It is needless to say that there is no polyester raised warp knitted fabric that satisfies the after-flame time of 3 seconds or less after setting a flame by a vertical method after 3 times
30 of washing, which is the flame retardancy standard of general covering of chair in the theaters in Europe, such as in Italy and Germany, though certain fabric satisfied the flame retardancy by laminating or coating the back of a polyester raised cloth with a flame-retardant agent.

35 Such product with a processed backing has difficulty in

feeling and a polyester raised warp knitted fabric superior in flame retardancy and feeling has not been obtained.

It is a first object of the present invention to provide a flame-retardant polyester fiber superior in dyeing property and mechanical property, such as abrasion resistance, heat stability and the like, which affords grace feeling and stable flame retardancy over a long period of time.

A second object of the present invention is to provide a flame-retardant polyester fiber having high flame retardancy and extremely fine whiteness.

A third object of the present invention is to provide a woven, knitted fabric and a nonwoven fabric using the above-mentioned unconventional and novel flame-retardant polyester fiber.

A fourth object of the present invention is to provide a suede raised woven, knitted fabric using the above-mentioned unconventional and novel flame-retardant polyester fiber, which affords high flame retardancy and a markedly improved feeling.

Disclosure of the Invention

The first invention of the present invention is a flame-retardant polyester fiber comprising a phosphorus compound copolymerized polyester satisfying the following formulas (1)-(3) and having a phosphorus atom content of 500-50,000 ppm:

$$\tan \delta_{\max} \geq 0.1740 \text{ (formula 1)}$$

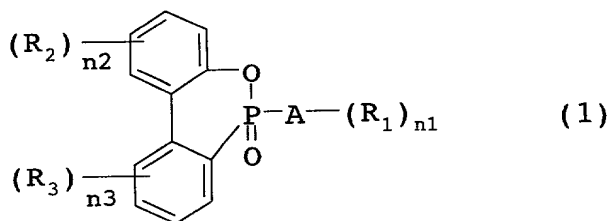
$$T\alpha - 3.77 \times \ln (\text{dtpf}) \leq 137.0 \text{ (formula 2)}$$

$$1.331 \leq SG - \frac{\sqrt{\Delta n}}{8.64} \leq 1.345 \text{ (formula 3)}$$

wherein $\tan \delta_{\max}$ is the maximum value of loss tangent in a dynamic viscoelasticity measurement, $T\alpha$ is a temperature at which loss tangent reaches the maximum, dtpf is single fiber fineness (dtex), SG is density (g/cm^3), and Δn is birefringence.

The second invention of the present invention is the flame-retardant polyester fiber of claim 1, which comprises a copolymerized polyester obtained by adding a phosphorus compound of the following formula (1):

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wherein R_1 is a monovalent ester-forming functional group, R_2 and R_3 are the same or different and each is selected from a halogen atom, a hydrocarbon group having 1 to 10 carbon atoms and R_1 , A is a divalent or trivalent organic residue, n_1 is 1 or 2 and n_2 and n_3 are each an integer of 0 to 4.

The third invention of the present invention is the flame-retardant polyester fiber of claim 1, which is characterized by not less than 6500 times up to the occurrence of cutting by abrasion under a load of 0.098 N/tex in a yarn abrasion test.

The fourth invention of the present invention is the flame-retardant polyester fiber of claim 1, which shows tensile elongation at break (DE) of 20-50%.

The fifth invention is the flame-retardant polyester fiber
15 of claim 1, which shows shrinkage in hot water (SHW) of not more
than 10%.

The sixth invention is the flame-retardant polyester fiber of claim 1, which satisfies the following formula 4, wherein L value is not less than 67 and b value is not more than 10.00 as measured with a Hunter's color-difference meter:

$$\%B.B. < 0.5 \quad (\text{formula 4})$$

wherein %B.B. is a proportion of ester bond broken upon immersion in a closed system in pure water at 130°C for 6 h, which can be determined by the following formula (5) wherein an intrinsic viscosity before immersion is $[\eta]_i$ and that after immersion is $[\eta]_f$, and the intrinsic viscosity is determined in a mixed solvent of phenol/1,1,2,2-tetrachloroethane (weight ratio 3/2) at 30°C:

$$\%B.B. = 0.244 \times \{[\eta]_f^{-1.471} - [\eta]_i^{-1.471}\} \text{ (formula 5).}$$

30 The seventh invention is the flame-retardant polyester

fiber of claim 1, wherein the phosphorus compound copolymerized polyester contains an organic fluorescent brightener in a proportion of 0.01-1 wt% and, as a condensation polymerization catalyst, an antimony compound, a germanium compound and a cobalt compound in amounts that simultaneously satisfy the following formulas (6)-(9):

$$30 \leq S \leq 400 \quad (\text{formula 6})$$

$$10 \leq G \leq 100 \quad (\text{formula 7})$$

$$5 \leq C \leq 40 \quad (\text{formula 8})$$

$$200 \leq S+2G+C \leq 400 \quad (\text{formula 9})$$

wherein S, G and C are each a content (ppm) of an antimony atom, germanium atom or cobalt atom relative to the polyester.

The eighth invention is a flame-retardant polyester woven, knitted fabric comprising the flame-retardant polyester fiber of claim 1 at least in a part thereof.

The ninth invention is a suede raised woven, knitted fabric wherein the flame-retardant polyester woven, knitted fabric of claim 8 has a coefficient of friction of a surface of the woven, knitted fabric by a surface tester KES-FB4 of 0.200-0.300.

The tenth invention is a flame-retardant polyester nonwoven fabric comprising the flame-retardant polyester fiber of claim 1 at least in a part thereof.

The present invention is explained in detail in the following.

The polyester in the present invention comprises terephthalic acid or naphthalenedicarboxylic acid as a main acid component and at least one glycol, preferably at least one alkylene glycol selected from ethylene glycol, trimethylene glycol and tetramethylene glycol, as a main glycol component. It may be a polyester wherein a part of the terephthalic acid component or naphthalenedicarboxylic acid component is substituted by a different bifunctional carboxylic acid component and/or a part of the glycol component is substituted by the above-mentioned glycol other than the main component or

other diol component.

Examples of the dicarboxylic acid include saturated aliphatic dicarboxylic acid as exemplified by oxalic acid, malonic acid, succinic acid, glutalic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, decanedicarboxylic acid, dodecanedicarboxylic acid, tetradecanedicarboxylic acid, hexadecanedicarboxylic acid, 1,3-cyclobutanedicarboxylic acid, 1,3-cyclopentanedicarboxylic acid, 1,2-cyclohexanedicarboxylic acid, 1,3-cyclohexanedicarboxylic acid, 1,4-cyclohexanedicarboxylic acid, 2,5-norbornanedicarboxylic acid, dimmer acid and the like and ester-forming derivatives thereof, unsaturated aliphatic dicarboxylic acid as exemplified by fumaric acid, maleic acid, itaconic acid and the like and ester-forming derivatives thereof, aromatic dicarboxylic acid as exemplified by orthophthalic acid, isophthalic acid, terephthalic acid, 5-(alkali metal)sulfoisophthalic acid, diphenic acid, 1,3-naphthalenedicarboxylic acid, 1,4-naphthalenedicarboxylic acid, 1,5-naphthalenedicarboxylic acid, 2,6-naphthalenedicarboxylic acid, 2,7-naphthalenedicarboxylic acid, 4,4'-biphenyldicarboxylic acid, 4,4'-biphenylsulfone dicarboxylic acid, 4,4'-biphenyl ether dicarboxylic acid, 1,2-bis(phenoxy)ethane-p,p'-dicarboxylic acid, pamoic acid, anthracene dicarboxylic acid and the like and ester-forming derivatives thereof. Of these dicarboxylic acids, terephthalic acid and naphthalenedicarboxylic acid, particularly 2,6-naphthalenedicarboxylic acid, are preferable.

Examples of polyhydric carboxylic acid other than these dicarboxylic acids include ethanetricarboxylic acid, propanetricarboxylic acid, butanetetracarboxylic acid, pyromellitic acid, trimellitic acid, trimesic acid, 3,4,3',4'-biphenyltetracarboxylic acid, and ester-forming derivatives thereof and the like.

Examples of glycol include aliphatic acid glycols such as ethylene glycol, 1,2-propylene glycol, 1,3-propylene glycol,

diethylene glycol, triethylene glycol, 1,2-butylene glycol, 1,3-butylene glycol, 2,3-butylene glycol, 1,4-butylene glycol, 1,5-pentanediol, neopentyl glycol, 1,6-hexanediol, 1,2-cyclohexanediol, 1,3-cyclohexanediol, 1,4-cyclohexanediol, 1,2-cyclohexanedimethanol, 1,3-cyclohexanedimethanol, 1,4-cyclohexanedimethanol, 1,4-cyclohexanediethanol, 1,10-decamethylene glycol, 1,12-dodecanediol, polyethylene glycol, polytrimethylene glycol, polytetramethylene glycol and the like, aromatic glycols as exemplified by hydroquinone, 4,4'-dihydroxybisphenol, 1,4-bis(β -hydroxyethoxy)benzene, 1,4-bis(β -hydroxyethoxyphenyl)sulfone, bis(p-hydroxyphenyl)ether, bis(p-hydroxyphenyl)sulfone, bis(p-hydroxyphenyl)methane, 1,2-bis(p-hydroxyphenyl)ethane, bisphenol A, bisphenol C, 2,5-naphthalenediol, these glycols added with ethylene oxide, and the like. Of these glycols, ethylene glycol and 1,4-butylene glycol are preferable.

The polyhydric alcohol other than these glycols is exemplified by trimethylolmethane, trimethylolthane, trimethylolpropane, pentaerythritol, glycerol, hexanetriol and the like.

Examples of hydroxycarboxylic acid include lactic acid, citric acid, malic acid, tartaric acid, hydroxyacetic acid, 3-hydroxybutyric acid, p-hydroxybenzoic acid, p-(2-hydroxyethoxy)benzoic acid, 4-hydroxycyclohexanecarboxylic acid, ester-forming derivatives of these and the like.

Examples of cyclic ester include ϵ -caprolactone, β -propiolactone, β -methyl- β -propiolactone, δ -valerolactone, glycolide, lactide and the like.

Examples of ester-forming derivatives of polyhydric carboxylic acid and hydroxycarboxylic acid include alkyl ester, acid chloride, acid anhydride and the like of these.

In the present invention, a polyester consisting of the above-mentioned dicarboxylic acid component and a diol component particularly preferably comprises an ethylene terephthalate or ethylene naphthalate unit in a proportion of not less than 80

mol%.

When improvement in the whiteness of a flame-retardant polyester fiber or a cloth is desired, which is one of the objects of the present invention, an antimony compound, a cobalt compound and a germanium compound are concurrently used in specific amounts as a condensation polymerization catalyst. To be specific, they are desirably used in amounts satisfying the following formulas (6)-(9):

$$\begin{array}{ll} 30 \leq S \leq 400 & \text{(formula 6)} \\ 10 \leq G \leq 100 & \text{(formula 7)} \\ 5 \leq C \leq 40 & \text{(formula 8)} \\ 200 \leq S+2G+C \leq 400 & \text{(formula 9)} \end{array}$$

wherein S, G and C are each a content (ppm) of antimony atom, germanium atom or cobalt atom relative to the polyester.

When the amount of the antimony compound added is less than the aforementioned range, the condensation polymerization becomes slow, and when it exceeds the above-mentioned range, the L value as measured with a Hunter's color-difference meter unpreferably decreases. Moreover, when a phosphorus compound is added in a large amount, the antimony compound is reduced by the phosphorus compound. The reduced product becomes a foreign substance and causes increased spinpack pressure during spinning, cutting of yarn, dirty nozzle surface and the like, thereby unpreferably exerting an extremely adverse influence on the spinning operability. One of the major effects of the present invention to reduce the amount of catalyst antimony is the improvement in the productivity.

When the amount added of the germanium compound is less than the above-mentioned range, the condensation polymerization becomes slow, and when it exceeds the above-mentioned range, the production cost becomes higher because germanium is extremely expensive, and the b value of the polymer unpreferably increases.

When the amount added of the cobalt compound is less than the above-mentioned range, the b value of the color tone of the resulting polymer becomes high, and when it exceeds the above-

mentioned range, the b value becomes too low and the L value tends to decrease unpreferably.

Furthermore, when G, S and C do not satisfy the aforementioned formula (9) and $S+2G+C$ is less than the above-mentioned range, the speed of the condensation polymerization becomes insufficient, and when it exceeds the above-mentioned range, the color tone and stability of the obtained polymer are degraded unpreferably.

According to the present invention, when to add the above-mentioned condensation polymerization catalyst is not subject to any particular limitation as long as it is before the start of the condensation polymerization, and the catalyst can be added according to a conventionally known method. For example, transesterification method, direct polymerization method, continuous polymerization method and the like can be used.

According to the production method of the flame-retardant polyester of the present invention, an additive generally used, such as tetraethylammonium hydroxide, organic amine and organic carboxylic acid amide, which are ether binding inhibitors, basic salt such as sodium acetate, lithium acetate and the like, and the like, titanium dioxide which is a matting agent, other flame-retardant auxiliary, pigment such as carbon black and the like, plasticizer, stabilizer, antistatic, orthochromatic agent and the like can be added concurrently.

According to the present invention, an organic fluorescent brightener can be used for improving the whiteness of a fiber. To be specific, a benzoxazole compound is preferable, and Hostalux KS (Clariant) is particularly preferable.

The amount of addition is 0.01 - 1 wt%, wherein an amount less than 0.01 wt% unpreferably leads to an insufficient whiteness-improving effect. Addition of 1 wt% or more of the brightener does not result in an improvement in the effect, and therefore, addition of 1 wt% or more is redundant. The amount is preferably 0.02 - 0.1 wt%.

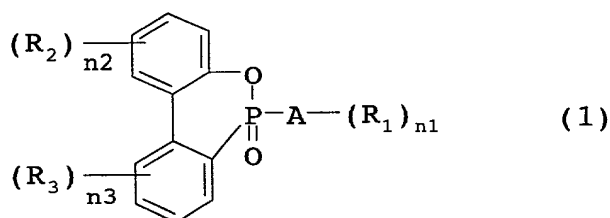
The aforementioned organic fluorescent brightener may

contain a blue dye for the purpose of improving the color tone.

The polymer to be used for the flame-retardant polyester fiber of the present invention is a polyester wherein a phosphorus compound containing phosphorus atom is copolymerized.

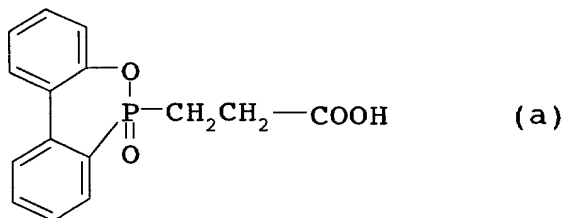
5 The phosphorus compound can react with dicarboxylic acid and diol, which are the constituent components of polyester, and can be copolymerized into polyester. Of the phosphorus compounds, a preferable compound is that which permits introduction of phosphorus atom into the side chain and/or terminal of the
10 polyester. A compound that permits introduction of phosphorus atom into the side chain is particularly preferable, because it disturbs crystallinity and the orientation of amorphous molecules.

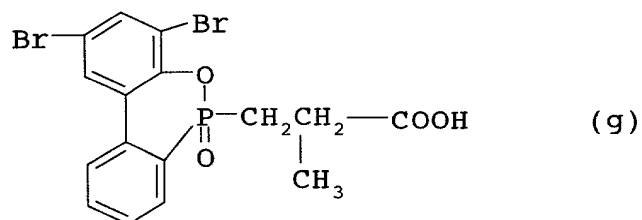
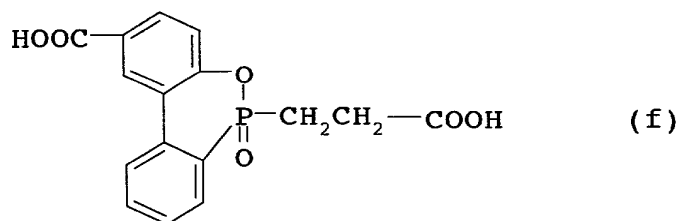
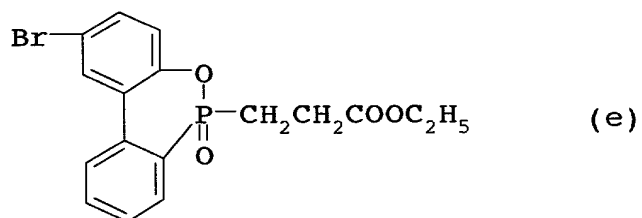
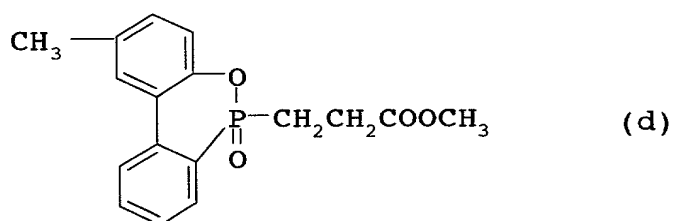
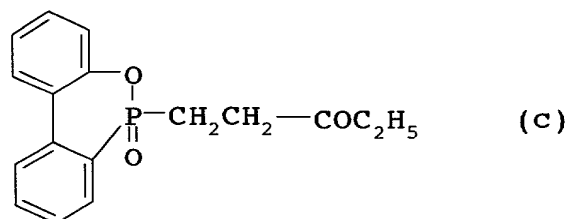
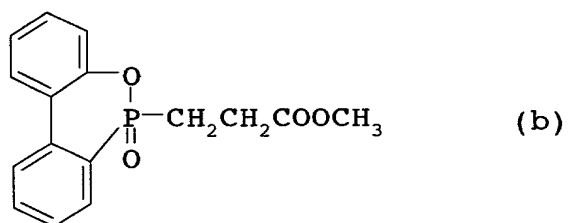
Examples of the phosphorus compound include the compound
15 of the formula (1).

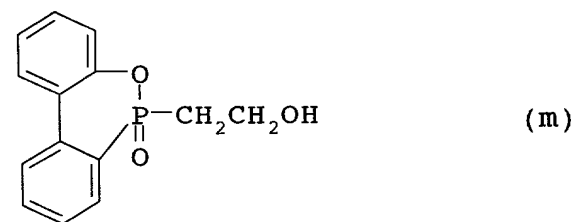
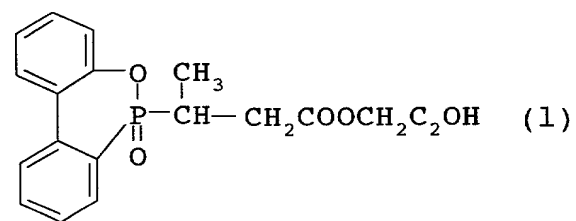
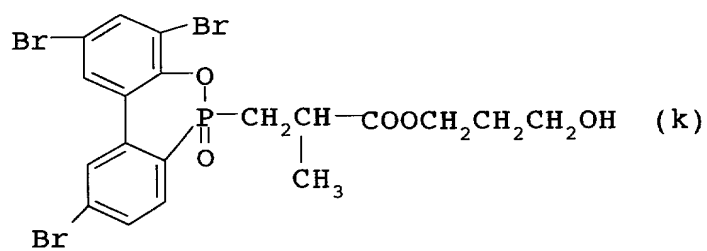
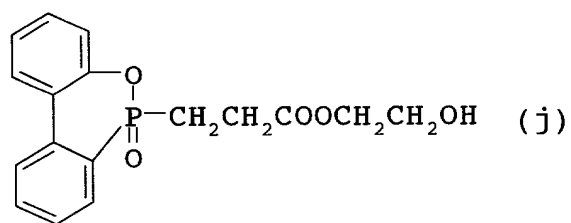
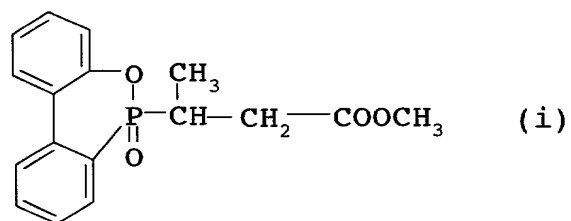
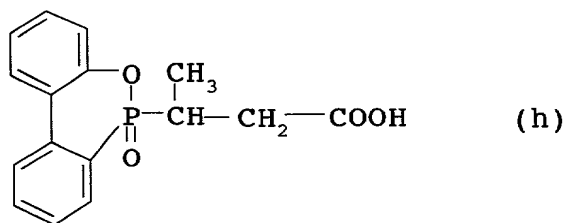


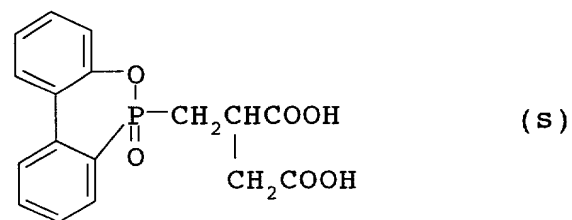
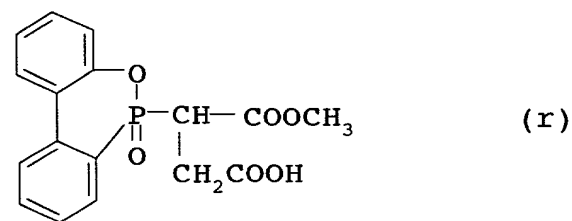
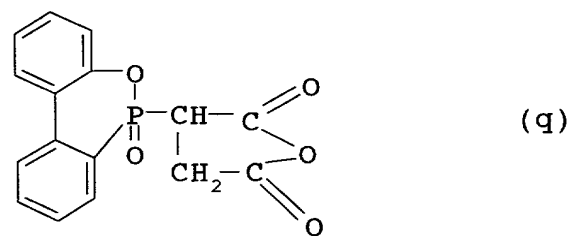
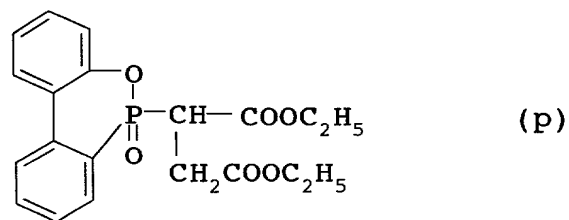
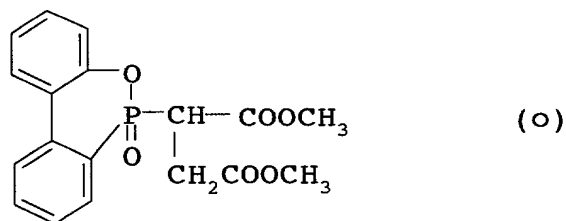
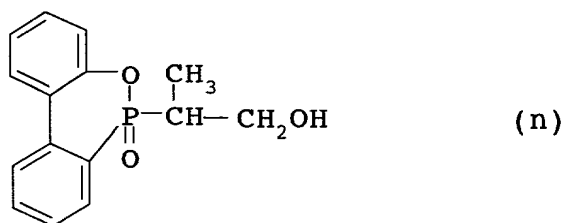
wherein R_1 is a monovalent ester-forming functional group, R_2 and R_3 are the same or different and each is selected from a halogen atom, a hydrocarbon group having 1 to 10 carbon atoms
20 and R_1 , A is a divalent or trivalent organic residue, n_1 is 1 or 2 and n_2 and n_3 are each an integer of 0 to 4.

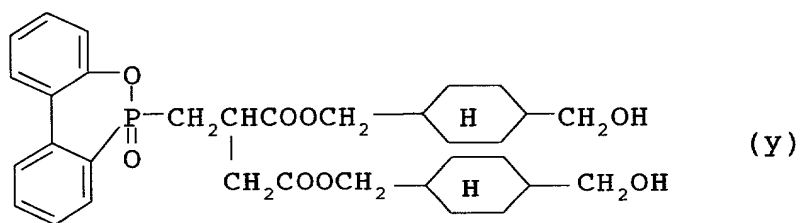
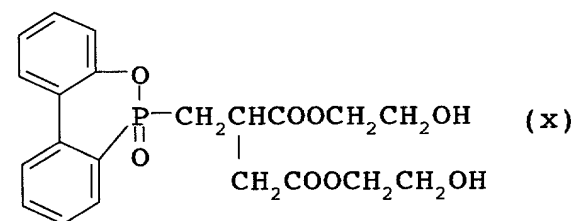
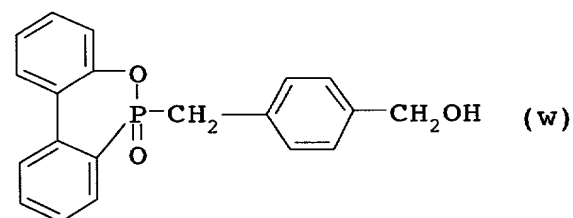
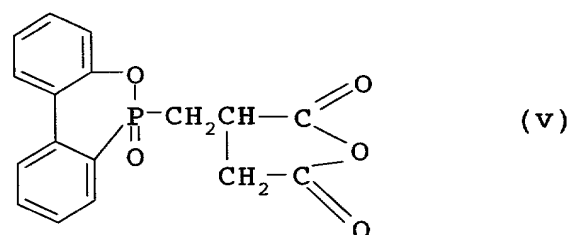
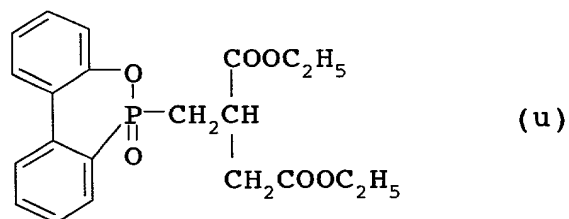
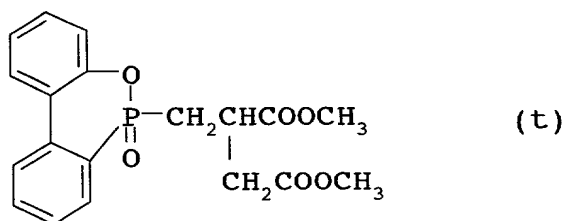
Specific examples of the compound of the formula (1) include the compounds of the following $\alpha - \beta$:

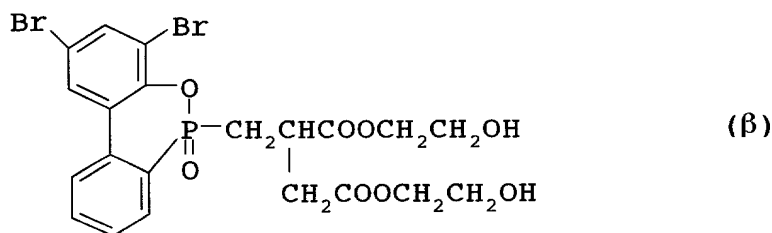
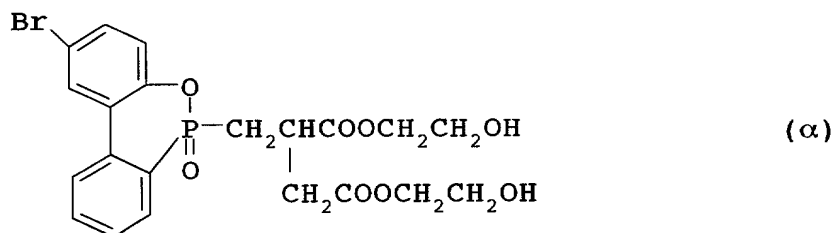
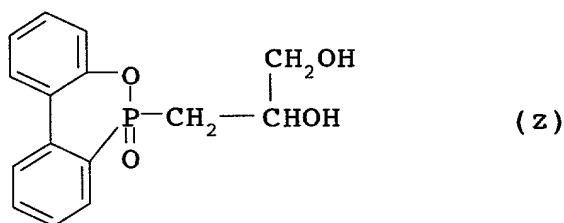












The copolymerized polyester to be used for the production of the flame-retardant polyester fiber of the present invention can be basically polymerized according to a known method described in, for example, JP-B-55-41610. The flame-retardant polyester fiber can be obtained by melt spinning including discharging a copolymerized polyester from a spinneret of a melt extruder, and taking up the polymer at a speed of 1000 m/min - 4500 m/min, preferably 1500 - 4000 m/min.

A completed yarn is obtained by any of a two-step method comprising spinning and draw-twisting, a one-step method which is a so-called spin-draw method, and a method comprising direct drawing with a non-contact heater after cooling the yarn. As important production conditions, the temperature of a spinneret surface is essentially set for 10°C to 30°C lower than the temperature set for general melt-spinning of polyethylene terephthalate. In general, when the spinning temperature is lowered, the viscosity of the polymer increases and the spinning

tension becomes higher. For the production of the flame-retardant fiber of the present invention, it is important to set the intrinsic viscosity of the polymer for 0.58 - 0.63 dl/g and reduce the viscosity during melting in order to make the spinning tension fall within a suitable range. Namely, spinning at a temperature similar to that generally employed for polyethylene terephthalate results in a noticeable decrease in the polymer viscosity, the polymerization degree and the spinning tension. A fiber thus obtained has lower tenacity and is poor in abrasion resistance. When the intrinsic viscosity is higher than 0.63 dl/g, the viscosity during melting becomes high and the tension during spinning becomes higher. As a result, orientation of molecule proceeds and the dyeing property becomes low. Conversely, when it is less than 0.58 dl/g, the spinning tension becomes extremely low, and so does the tenacity, whereby the initial object of the present invention becomes difficult to achieve.

The shear rate of the discharged polymer should be 3000 - 9000 s^{-1} to control molecular orientation and to avoid cutting of yarn. When it is less than 3000 s^{-1} , the molecular orientation becomes insufficient in the melting state, and the obtained fiber has lower tenacity and poor abrasion resistance. When the draw ratio is increased with the hope of resolving such defects, the obtained fiber comes to show degraded dyeing property. When it conversely exceeds 9000 s^{-1} , soil on the spinneret surface, particularly around orifice, becomes intense. This causes easy occurrence of cut yarn. In either case, the object of the present invention becomes difficult to achieve. The preferable value is 3500 - 8500 s^{-1} .

The distance from the spinneret surface to the cooling air outlet should be not more than 80 mm, preferably not more than 70 mm. This is preferable because molecule arrangement of a completed yarn can be lowered by increasing the spinning tension by cooling as soon as possible after the polymer is discharged, thereby allowing the drawing under high deformation speed of the

spinning to proceed as much as possible, and decreasing the draw ratio under the low deformation speed in the subsequent drawing step. When it exceeds 80 mm, cooling of the yarn becomes late and the spinning tension becomes lower. Thus, the drawing by
5 spinning does not proceed to make the draw ratio in the drawing step higher, which in turn makes the molecular orientation higher and the dyeing property degraded. This has a consequence that the fiber has a $\tan \delta$ max of less than 0.250 and the objective fiber of the present invention is difficult to obtain.
10 The temperature for the setting during the drawing step is preferably not less than 155°C. When it is less than 155°C, the setting becomes insufficient and the heat stability is degraded.

A fiber having dyeing property and mechanical property, that are difficult to achieve with a conventional flame-
15 retardant polyester fiber, can be obtained for the first time by employing the aforementioned specific production conditions and the like.

The copolymerized polyester used for the flame-retardant polyester fiber of the present invention preferably has a
20 phosphorus atom content of 500 - 50,000 ppm. When it is less than 500 ppm, the fiber shows poor flame retardancy and makes disperse dyeing at atmospheric pressure difficult. When it exceeds 50,000 ppm, it means that the amount to be copolymerized of the phosphorus compound containing phosphorus atom has been
25 increased. Consequently, the melting point of the polymer becomes dramatically low, making the spinning difficult, and the resulting fiber shows low tenacity, which is not preferable. It is more preferably 1,500 - 30,000 ppm, still preferably 3,000 - 10,000 ppm.

30 The flame-retardant polyester fiber of the present invention preferably has a $\tan \delta$ max of not less than 0.1740. When it is less than 0.1740, dyeing property becomes extremely low to the degree that the required level cannot be met. As regards filament, however, the required level of dyeing property
35 is high and the $\tan \delta$ max needs to be not less than 0.220. When

it is less than 0.220, the degree of exhaustion of dye becomes low and so does abrasion resistance, because the region of amorphous part is small and mobility is low. It is preferably not less than 0.230. The upper limit of $\tan \delta$ max is not particularly limited, but when this value is too high, the crystallinity is greatly destroyed and may affect the tenacity of the yarn. The temperature ($T\alpha$) of the $\tan \delta$ max should satisfy the following formula (2):

$$T\alpha - 3.77 \times \ln(dtpf) \leq 137.0 \quad (\text{formula 2})$$

When the temperature is outside this range, the dyeing property becomes profoundly degraded. It is more preferably not more than 135. While the lower limit is not particularly limited, too low a limit results in poor heat resistance. It is preferably not less than 65.

The flame-retardant polyester fiber of the present invention desirably satisfies the following formula (3):

$$1.331 \leq SG - \frac{\sqrt{\Delta n}}{8.64} \leq 1.345 \quad (\text{formula 3})$$

When the value is lower than this range, the molecular orientation degree relative to the degree of crystallinity becomes higher, the amorphous portion becomes dense, and the fiber becomes inferior in dyeing property and abrasion resistance. Conversely, when the value is higher than this range, the degree of molecular orientation relative to the degree of crystallinity becomes too low, which in turn results in superior dyeing property but lower heat stability because shrinkage in boiling water grows as the fiber tenacity decreases. It is more preferably the following range.

$$1.333 \leq SG - \frac{\sqrt{\Delta n}}{8.64} \leq 1.342$$

The elongation at break (DE) is preferably 20% - 50%. When it is less than 20%, abrasion resistance is degraded and the nap is raised during post-processing. When it exceeds 50%, the fiber shows decreased heat stability and dimensional

instability because the yarn is unnecessarily drawn by the tension during the knitting and weaving steps. It is more preferably 25% - 45%.

The flame-retardant polyester fiber of the present invention preferably shows abrasion resistance as expressed by not less than 6500 times of reciprocating motion of a friction block. When it is less than 6500 times, the nap, whitening and the like occur in a post-processing step, whereby the initial object of the present invention becomes difficult to achieve. It is more preferably not less than 6700 times.

The flame-retardant polyester fiber of the present invention preferably shows shrinkage in boiling water (SHW) of not more than 10%, more preferably not more than 9%. When the SHW exceeds 10%, the fiber shows poor heat stability, marked dimensional changes in the subsequent steps, and rough and hard feeling of cloth, which makes the object of the present invention difficult to achieve.

The fiber as used in the present invention includes any form such as filament and staple.

A fiber superior in whiteness, which is one aspect of the flame-retardant polyester fiber of the present invention, shows not less than 67 of an L value as measured with a Hunter's color-difference meter. In this event, a matting agent such as titanium oxide and the like or other matting agent etc. may be added. When the L value of the polyester fiber is less than 67, the fiber is not preferable for a use requesting extremely high whiteness, such as clothing, interior use such as suede raised woven and knitted fabrics to be mentioned later, and the like.

The flame-retardant polyester fiber of the present invention desirably has resistance to hydrolysis in the range of the aforementioned formula (4).

When the resistance to hydrolysis is greater than the range of the formula (4), the tenacity as a fiber or cloth may decrease during passage through subsequent steps such as dyeing and the like, which unpreferably causes poor passage of steps

and impaired property of the product.

The copolymerized polyester fiber of the present invention has an optional size of from extremely fine (single yarn fineness of not more than 1 dtex) to extremely thick (single
5 yarn fineness of 100 dtex or above). It may be applied to false-twisting and crimp, and the section of the fiber may be round, tri-lobal, hollow, flat, multi-lobal and the like. Conjugate spinning with other polyester, polyethylene, polyamide and the like is also possible.

10 One of the preferable uses of the flame-retardant polyester fiber of the present invention is, for example, suede raised woven and knitted fabrics. In this case, the fiber fineness is set for not more than 1.0 dtex, preferably 0.1 - 0.7 dtex. When the fineness exceeds 1.0 dtex, an improvement in the
15 feeling, which is one of the objects of the present invention, cannot be achieved.

The above-mentioned flame-retardant polyester fiber can be used in at least one part of a woven fabric, or a non-woven fabric. When a suede raised woven, knitted fabric is to be
20 produced, plain weave, twill weave, satin weave and the like are exemplified, preferably satin weave.

The knitted fabric in the present invention is a fabric made by the combination of knit, welt and tuck, and is exemplified by tack stitch, gray sheeting, Mock rodier and the
25 like, with preference given to Mock rodier.

The suede woven and knitted fabrics of the present invention need to be subjected to raising. As a raising method, a typical raising method can be employed and the raising machine may use teasel, card cloth, sand paper and the like, which may
30 be of a wet or dry type.

As the raising machine, a card cloth raising machine is preferable. Of the card cloth raising machines, a complex action type card cloth raising machine is more preferable, wherein a pile roll with a needle pointing toward the direction
35 of cylinder rotation and a counterpile roll with a needle

pointing opposite are alternately set. In the case of a knitted fabric, a hydraulic high torque card cloth raising machine is more preferable, and in the case of a woven fabric, a card cloth raising machine that permits positive and reverse rotation of a cylinder is more preferable.

For raising, woven and knitted fabrics may be passed through a raising machine only once, but for uniform raising and improved feeling, stronger raising is successively applied while considering the tenacity of the woven and knitted fabrics, and several repeats or more of the raising is preferably applied. The raising is preferably applied not only to the surface of the woven and knitted fabrics but also to the back thereof.

The suede woven and knitted fabrics of the present invention show strikingly soft feeling as compared to conventional suede woven and knitted fabrics. The fabrics show a coefficient of friction (μ) as measured with a KES-FB4 surface tester known as a KES (Kawabata's Evaluation System for Fabrics) feeling measurement, of within the range of approximately 0.200 - 0.300. It is preferably 0.200 - 0.270, and more preferably, the average value in the knitting direction and the opposite direction is 0.200 - 0.250.

The coefficient of friction (μ) can be defined as follows according to the instruction manual of a KES-FB4 surface tester:

$$\mu = F/P$$

wherein F is a frictional force and P is a standard load of a friction block that presses a cloth specimen.

The μ value varies during the period when a friction block moves on the surface of cloth. Therefore, an average coefficient of friction μ_a can be defined by the following formula:

$$\mu_a = \frac{1}{L_{\max}} \times \int_0^{L_{\max}} \mu \cdot dL$$

The variation in the coefficient of friction is shown by average deviation MMD:

$$MMD = \frac{1}{L_{\max}} \times \int_0^{L_{\max}} |\mu - \mu_a| \cdot dL$$

As regards the variation in the coefficient of friction (MMD) of the suede woven and knitted fabrics of the present invention, when the degree of variation in the coefficient of friction as compared between that in the knitting direction and that in the opposite direction of a raised woven, knitted fabric as measured with a KES-FB4 surface tester is direction of knitting \geq the opposite direction, feeling and the touch of the suede woven, knitted fabric is extremely soft. When it is knitting direction $<$ opposite direction, the touch tends to be degraded even if the fabric is soft. Therefore, the variation in the coefficient of friction (MMD) in the knitting direction is preferably made as small as possible.

The correlation between the aforementioned coefficient of friction and the variation thereof as measured with the KES-FB4 surface tester, as well as a touch by human showed appreciable consistency as shown in the following examples.

The woven and knitted fabrics of the present invention do not require an immersion treatment of polyurethane resin, which is generally applied to a suede woven, knitted fabric, but where necessary, may be subjected to immersion of the polyurethane resin, after which raising is applied.

To exhibit the flame retardancy of the aforementioned raised woven and knitted fabrics, the fabric is desirably subjected to exhaustion processing with 5 - 15% owf of an emulsion and/or dispersion of phosphorus and/or halogen compound in the same bath during the dyeing process after the aforementioned raising processing. As the emulsion and/or dispersion of phosphorus and/or halogen compound, there are mentioned an emulsion and/or aqueous dispersion of phosphoric acid ester such as phosphorus and/or alkyl halide, aryl halide, alkylaryl halide and the like and alicyclic bromide compound, such as hexabromocyclododecane and the like. The raised woven, knitted fabric after exhaustion processing shows not more than 3

seconds of after-flame time by the following test method.

A flame of a lighter is drawn up to the bottom end of a specimen (1.5 cm x 20 cm) stood vertically and the flame is drawn back when the specimen is inflamed. At the same time, the after-flame time of the specimen is measured (n=10 times).

The flame-retardant polyester fiber of the present invention can be combined with a known flame-retardant agent in an attempt to increase the flame retardancy. The combination here means, for example, a method comprising adding a flame-retardant agent during polymer production for copolymerization or blending, a method comprising kneading in of a flame-retardant agent during spinning, a method comprising post-processing the polyester fiber to adhere a flame-retardant agent to the surface of a fiber or permeate the agent into the fiber and the like.

Examples of the blend type flame-retardant agent include halogen flame-retardant agents such as bromine compounds (e.g., tetrabromobisphenol (TBA), decabromodiphenyloxide (DBDPO), hexabromocyclododecane (HBCD), octabromodiphenyloxide, bistribromophenoxyethane (BTBPE), tribromophenol (TBP), ethylenebistetrabromophthalimide, TBA polycarbonate oligomer, polystyrene bromide, TBA epoxy oligomer or polymer, decabromodiphenylethane, polydibromophenyloxide, hexabromobenzene and the like), chlorine compounds such as chlorinated paraffin, perchlorocyclopentadecane and the like, and the like. In addition, there are mentioned phosphoric flame-retardant agents such as phosphoric acid esters, halogen-containing phosphoric acid esters, polyphosphate, red phosphorus and the like, silicone flame-retardant agents such as silicone polymer powder and the like, and organic flame-retardant agents such as triazine compound, melanin cyanurate, guanidine compound and the like. Moreover, there are exemplified inorganic flame-retardant agents such as antimony trioxide, aluminum hydroxide, nitrogenized guanidine, antimony pentaoxide, magnesium hydroxide, zinc borate, zirconium compound, calcium aluminate, ammonium

phosphate, ammonium carbonate, molybdenum compound, zinc stannate and the like. The above-mentioned flame-retardant agents are not limited to those recited and may be derivatives thereof or analogs. These flame-retardant agents may be used
5 alone or in combination.

The flame-retardant polyester fiber of the present invention can be used for various uses such as suede raised woven and knitted fabrics and the like, as a woven, knitted fabric or a nonwoven fabric. That is, it is applicable to any
10 use in the field requesting flame retardancy, as long as fiber property superior in dyeing property, abrasion resistance, and further, whiteness can be utilized.

Best Mode of Embodiment of the Invention

The present invention is explained in the following by
15 referring to Examples. The following methods were used for the evaluation in the present invention.

dynamic viscoelasticity

Using Rheovibron (DDV-01FP; Orientech), loss tangent ($\tan \delta$) was measured under 110 Hz frequency while elevating the
20 temperature from 20°C to 230°C at a rate of 1°C/min. Based on the maximum value thereof as $\tan \delta_{\max}$, the temperature at which the maximum value was shown was taken as T_{α} for evaluation.

density; SG

Measured using a density gradient tube containing a
25 mixture of calcium nitrate 4 hydrate and pure water at 30°C, and the average value ($n=3$) was taken as the density.

birefringence; Δn

The average value ($n=5$) as measured with a polarization microscope equipped with a Berek compensator based on the
30 retardation and fiber diameter was taken as this value.

tenacity, elongation; DE

The tenacity and elongation were measured 5 times each by Tensilon (Orientech) under the conditions of gauge length 200 mm and crosshead speed 200 mm/min, and the average values were used
35 for evaluation.

abrasion resistance test

Basically following JIS-L1095 (7.10.2 B method) and using a yarn abrasion tester, a friction block was reciprocated at a load of 0.098 N/tex and abrasion rate of 115 times/min. The number of reciprocation until breakage was measured and evaluated by the average (n=10).

shrinkage in boiling water

A load corresponding to fineness (dtex) \times 1/33.3 g was applied, the original yarn was marked at the length of 50.0 cm and wrapped in gauze, after which the fiber was immersed in boiling water for 30 min. After air drying, the same load was applied and the length (L) between the marks was measured, based on which the shrinkage was calculated according to the following formula:

$$\text{SHW (\%)} = (50-L)/50 \times 100$$

evaluation of flame retardancy

According to JAPAN fire protection law No. 65, evaluated at a limiting oxygen index (LOI).

L*; lightness

Using a spectrophotometer (Minolta CM-3700D), L* value was measured 3 times at measurement diameter 8 mm ϕ , light source D65 and visual field 2°, and the average value was used for the evaluation.

color fastness to light

A specimen was exposed to irradiation with an ultraviolet long life fadometer (FAL-AU/H/BR) at irradiation temperature (BPT); 63 \pm 3°C for 40 hours to cause color fading by light, which was followed by evaluation of grade according to the gray scale standard.

intrinsic viscosity [IV]

Measured in phenol/1,1,2,2-tetrachloroethane mixed solvent (weight ratio 3:2) at 30°C and the intrinsic viscosity was determined from the relative viscosity by a conventional method.

color tone (L value, b value)

The L value and b value showing the color tone of the

A warp knitted fabric was cut out in 1.5 cm × 20 cm in the warp direction and the weft direction and used as a specimen. A flame of a lighter was drawn up to the bottom end of the specimen stood vertically and the flame was drawn back when the specimen was inflamed. At the same time, the after-flame time of the specimen was measured. The measurement was done 5 times each for the warp direction and the weft direction of the specimen.

Example 1

Terephthalic acid as a carboxylic acid component, ethylene glycol as a glycol component and the aforementioned phosphorus-containing compound(s) were copolymerized to give phosphorus atom-containing copolymerized polyester having a phosphorus atom content of 6000 ppm. The obtained polyester was melt-spun at a spinning temperature 262°C, shear rate 6010 s⁻¹, take-up speed 1450 m/min and the distance from the spinneret surface to the cooling air outlet 65 mm, after which it was drawn 2.79 times under conventional conditions to give a 167 dtex, 48 filament complete yarn. The obtained yarn was processed to give a tubular knit fabric and subjected to scouring. After air drying, it was dyed with a disperse dye (Dianix Black BG-FS200%; DyStar Japan) under the conditions of bath ratio 1:50, dye density 20% owf at 130°C for 60 min. After drying, the lightness (L*) was measured with a colorimeter and color fastness to light was evaluated. The obtained cloth was superior in dyeing property and color fastness to light, not to mention flame retardancy. It was also superior in abrasion resistance of the yarn (see Table 1).

Example 2

In the same manner as in Example 1 except that the shear rate was 4307 s⁻¹, take-up speed was 1300 m/min and draw ratio was 2.88 times to give a 56 dtex, 24 filament complete yarn, a cloth was obtained. The obtained cloth was superior in dyeing property and color fastness to light, not to mention flame retardancy. It was also superior in abrasion resistance of the

yarn (see Table 1).

Example 3

In the same manner as in Example 1 except that the shear rate was 3676 s^{-1} , take-up speed was 3000 m/min, distance from the spinneret surface to the cooling air outlet was 35 mm and draw ratio was 1.67 times to give a 84 dtex, 24 filament complete yarn by a spin-draw method, a cloth was obtained. The obtained cloth was superior in dyeing property and color fastness to light, not to mention flame retardancy. It was also superior in abrasion resistance of the yarn (see Table 1).

Example 4

In the same manner as in Example 1 except that the phosphorus atom content was 3500 ppm and spinning temperature was 265°C , a 167 dtex, 48 filament complete yarn was obtained. The obtained cloth was superior in dyeing property and color fastness to light, not to mention flame retardancy. It was also superior in abrasion resistance of the yarn (see Table 1).

Example 5

In the same manner as in Example 1 except that the draw ratio for drawing was 3.4 times, a complete yarn was obtained. The obtained yarn was superior in flame retardancy, dyeing property and color fastness to light, but inferior in abrasion resistance. In addition, nap was produced during knitting and the problem of difficult knitting remained (see Table 1).

Example 6

In the same manner as in Example 1 except that the draw ratio for drawing was 2.1 times, a complete yarn was obtained. The obtained yarn was superior in flame retardancy, dyeing property, abrasion resistance and color fastness to light, but showed dimensional changes due to the tension during knitting. Thus, the problem of inferior knitting property remained (see Table 1).

Example 7

In the same manner as in Example 1 except that the setting temperature during drawing was 145°C , a complete yarn was

obtained. The obtained cloth was superior in flame retardancy, dyeing property, abrasion resistance and color fastness to light, but showed poor dimensional stability against heat, and after dyeing, it showed rough and hard feeling, thus leaving a problem
5 (see Table 1).

Example 8

In the same manner as in Example 1 except that the spinning temperature was 262°C, shear rate was 8417 s⁻¹, take-up speed was 2450 m/min, distance from the spinneret surface to the
10 cooling air outlet was 25 mm, preheated roller temperature was 85°C, set roller temperature was 150°C and draw ratio was 1.63 to give a 100 dtex, 216 filament complete yarn by spin-draw method, a cloth was obtained. The obtained cloth was superior in dyeing property and color fastness to light, not to mention flame
15 retardancy. It was also superior in abrasion resistance of the yarn (see Table 1).

Example 9

A polymer was delivered from a 4350 hole spinneret at a spinning temperature 265°C, and spun at a take-up speed 1263
20 m/min. The obtained 14486 dtex tow was drawn-set, crimped with a crimper and cut to give a short fiber. After opening, it was subjected to carding to give a card web having a single fiber fineness 1.7 dtex and average fiber length 5.1 mm. The obtained short fiber had a tenacity of 4.61 cN/dtex, elongation of 27.5%,
25 tan δ max of 0.1745, T_α of 135.5°C, density of 1.3841 g/cm³ and An of 0.166. The obtained web was extremely superior in flame retardancy.

Comparative Example 1

In the same manner as in Example 1 except that a
30 phosphorus atom-containing copolymerized polyester having a phosphorus atom content of 300 ppm was used and the spinning temperature was 269°C, a complete yarn was obtained. The obtained yarn was superior in dyeing property and flame retardancy (see Table 1).

Comparative Example 2

In the same manner as in Example 1 except that a phosphorus atom-containing copolymerized polyester having a phosphorus atom content of 60000 ppm was used, the spinning temperature was 260°C and draw ratio was 2.59 times, a complete yarn was obtained. The yarn was frequently cut during spinning and drawing, and was problematic in operability. The obtained yarn was superior in dyeing property and flame retardancy but inferior in tenacity and abrasion resistance (see Table 1).

Comparative Example 3

In the same manner as in Example 1 except that the distance from the spinneret surface to the cooling air outlet was 120 mm and draw ratio was 2.92 to give a complete yarn, a cloth was obtained. The obtained fiber showed a low $\tan \delta$ max of 0.237, and the obtained cloth was inferior in dyeing property (see Table 1).

Comparative Example 4

In the same manner as in Example 1 except that the shear rate was 2161 s^{-1} , a complete fiber was obtained. The obtained fiber showed a low $\tan \delta$ max of 0.231 and was inferior in tenacity and abrasion resistance (see Table 1).

Comparative Example 5

In the same manner as in Example 1 except that the shear rate was 12603 s^{-1} , spinning was tried. However, the yarn was frequently cut during spinning and a fiber was not obtained (see Table 1).

Comparative Example 6

In the same manner as in Example 1 except that (2-carboxyethyl)methylphosphine acid was used as the phosphorus atom-containing compound to give a complete yarn, a cloth was obtained. The obtained fiber showed a low $\tan \delta$ max of 0.230, and the cloth was inferior in dyeing property. Moreover, the yarn showed inferior abrasion resistance (see Table 1).

Example 10

In a stainless autoclave equipped with a stirrer, a distillation column and a pressure regulator were charged

terephthalic acid (1242 parts), phosphorus compound (x) (117 parts, as 50% ethylene glycol solution) and ethylene glycol (850 parts), and antimony trioxide (24.1 parts, as 14 g/L ethylene glycol solution), germanium dioxide (15 parts, as 8 g/L ethylene glycol solution), triethylamine (5.2 parts), and titanium dioxide (22 parts, as 23.5% ethylene glycol solution) were added. While removing water generated during esterification, the esterification reaction was conducted at 230°C, gauge pressure 2.5 kg/cm² for 2 h. Then, cobalt acetate 4 hydrate (9.6 parts, as 20 g/L ethylene glycol solution) was added and the temperature of the system was raised to 275°C over 1 h, during which period the pressure of the system was gradually reduced to 0.1 mmHg and under these conditions, condensation polymerization was carried out for 1 h. The obtained polymer had an intrinsic viscosity of 0.65 and a phosphorus content of 3500 ppm. This polymer was spun and drawn by a conventional method and the obtained 56 dtex, 24 filament (tan δ max: 0.252, T α : 130.3°C, density : 1.3785 g/cm³, Δn : 0.119) was prepared into a knit sample. The spinning operability was fine. The %B.B. showing the flame retardancy and resistance to hydrolysis and color tone were measured. The results are shown in Table 2.

Example 11

In the same manner as in Example 9 except that the amount of catalyst was changed as shown in Table 1 and a fluorescent brightener (HostaluxKS: Clariant, 16.5 parts, as 2 wt% ethylene glycol solution) was added after esterification, the same operation as in Example 1 was performed. The results are shown in Table 2. The spinning operability was fine.

The obtained fiber showed tan δ max of 0.251, T α of 130.1°C, density of 1.3787 g/cm³, and Δn of 0.122.

Example 12

In the same manner as in Example 9 except that the phosphoric content was changed to the value corresponding to phosphorus atom of 6000 ppm and a fluorescent brightener (HostaluxKS: Clariant, 16.5 parts, as 2 wt% ethylene glycol

solution) was added after esterification, the same operation as in Example 1 was performed. The results are shown in Table 2. The spinning operability was fine.

The obtained fiber showed $\tan \delta$ max of 0.267, $T\alpha$ of 128.9°C, density of 1.3777 g/cm³, and Δn of 0.110.

Example 13

In the same manner as in Example 9 except that the kind of phosphorus, phosphoric content and the catalyst amount were changed as shown in Table 2 and a fluorescent brightener (HostaluxKS: Clariant, 16.5 parts, as 2 wt% ethylene glycol solution) was added after esterification, the same operation as in Example 1 was performed. The results are shown in Table 1. The spinning operability was fine.

The obtained fiber showed $\tan \delta$ max of 0.262, $T\alpha$ of 129.0°C, density of 1.3773 g/cm³, and Δn of 0.122.

Example 14

The aforementioned compound S was used as a phosphorus-containing compound and terephthalic acid and ethylene glycol were used as starting materials for polymerization wherein the phosphorus atom content was 6,000 ppm. Using the obtained phosphorus-containing copolymerized polyester, multifilaments of the phosphorus-containing polyester superfine fiber having a single fiber fineness of 0.36 dtex ($\tan \delta$ max: 0.223, $T\alpha$: 120.1°C, density: 1.3735 g/cm³, Δn : 0.109), 0.46 dtex ($\tan \delta$ max: 0.236, $T\alpha$: 121.8°C, density: 1.3716 g/cm³, Δn : 0.118) and 0.65 dtex ($\tan \delta$ max: 0.253, $T\alpha$: 122.0°C, density: 1.3716 g/cm³, Δn : 0.107) were obtained. These multifilaments were double-twisted into a total fineness of 167 dtex and a Mock rodier tubular knitted fabric was obtained, which included these phosphorus-containing polyester superfine fibers as a pile part and regular polyethylene terephthalate fibers (multifilament of single fiber having fineness 2.2 dtex, 56 dtex) as a ground part. The knitting conditions were number of needles 28 gauge, knitting diameter 33 inch, pile part/ground part = 35/65 (weight ratio). The weight of the cloth per meter was 500 g.

For comparison, a Mock rodier tubular knitted fabric was obtained, which included multifilaments of regular polyethylene terephthalate (0.36 dtex) as the pile part. The knitted fabric was dyed with disperse dyes (Foron Yellow Brown 1.0% owf, Foron Red RDGL 0.3% owf, Foron Navy S2GL 1.2% owf, Clariant Japan), a dispersing agent (IONET RAP Sanyo Chemical Industries, 0.5 cc/l), and acetic acid (80% solution, 0.5 cc/l), at a bath ratio 1:30 and dyeing temperature 130°C for 60 min, after which it was allowed to cool, washed and dried.

The obtained dyed knitted fabric was subjected to raising of both surfaces (application of raising: front 8 times, back 2 times) using a hydraulic raising machine (NIKKISO Co., Ltd.). The obtained raised knitted fabric was applied to measurement with a surface tester KES-FB4, the results of which are shown in Table 3.

The feeling was evaluated by 10 panelists by rating each knitted fabric as superior ◎, fine O, rather inferior Δ or inferior x.

The raised knitted fabric of the present invention showed lower coefficient of friction in both knitting direction and opposite direction as compared to Comparative Example using a regular polyethylene terephthalate fiber. It is clear that the variation in the coefficient of friction is small between the knitting direction and the opposite direction, wherein a smaller variation in the opposite direction means more superior feeling.

Example 15

Using a 3-reed 28G tricot warp knitting machine, a compound of the chemical formula (S) as a phosphorus-containing compound, and terephthalic acid and ethylene glycol were used as starting materials for polymerization wherein the phosphorus atom content was 6,000 ppm. The obtained phosphorus-containing copolymerized polyester was spun, and the obtained 84 dtex/72f (tan δ max: 0.253, $T\alpha$: 126.7°C, density: 1.3774 g/cm³, Δn : 0.116) and 56 dtex/24f (tan δ max: 0.257, $T\alpha$: 128.7°C, density: 1.3770 g/cm³, Δn : 0.105) were set on all reeds and knitted under

the following conditions.

Font reed: 84 dtex 72f 1-0/3-4

Middle reed: 56 dtex 24f 1-0/2-3

Middle reed: 56 dtex 24f 1-0/1-2

5 Surface knit density: 72 course \times 28 wale
knitting width : 267 cm

This grey fabric was subjected to raising, relax scouring,
dyeing, drying, finish setting to give a raised dyed finished
warp knitted fabric having finish width 150 cm, finish density
10 68 course \times 47 wale.

In the above-mentioned dyeing step, the fabric was
exhausted with an emulsion of 10% owf amount of phosphorus,
halogen compound in the same bath. The obtained warp knitted
fabric was measured for the after-flame time to examine flame
15 retardancy. As a result, the fabric showed 0 sec, 0 sec, 0 sec,
0.6 sec and 0.4 sec in the warp direction and 0.4 sec, 0 sec,
0.6 sec, 0.8 sec and 0 sec in the weft direction.

Example 16

In the same manner as in Example 14, 70 dtex/108f ($\tan \delta$
20 max: 0.222, $T\alpha$: 120.3°C, density: 1.3738 g/cm³, Δn : 0.112), and
33 dtex/24f ($\tan \delta$ max: 0.252, $T\alpha$: 126.3°C, density: 1.3778 g/cm³,
 Δn : 0.118) were obtained using a 2-reed 32G tricot warp knitting
machine, and set on all the reeds for knitting under the
following conditions:

25 Front reed: 70 dtex 108f 1-0/3-4
Middle reed: 33 dtex 24f 1-0/2-3
Fabric density: 90 course \times 32 wale
knitting width: 329 cm

This grey fabric was subjected to raising, relax scouring,
30 dyeing, drying, finish setting to give a raised dyed finished
warp knitted fabric having finish width 150 cm, finish density
80 course \times 67 wale.

In the above-mentioned dyeing step, the fabric was
exhausted with an emulsion of 10% owf amount of phosphorus,
35 halogen compound in the same bath. The obtained warp knitted

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5 fabric was measured for the after-flame time to examine flame retardancy. As a result, the fabric showed 0 sec, 0 sec, 0 sec, 0 sec and 0.4 sec in the warp direction and 0.4 sec, 0 sec, 0 sec, 0.6 sec and 0.7 sec in the weft direction.

Industrial Applicability

According to the present invention, a flame-retardant polyester fiber superior in dyeing property, abrasion resistance and heat stability and having stable flame retardancy for a long
10 time, as well as a flame-retardant polyester fiber having high flame retardancy, fine whiteness and resistance to hydrolysis can be produced economically and efficiently. The raised woven and knitted fabrics using the fiber show soft surface touch, have high-grade suede appearance and superior durability against
15 friction, abrasion and the like, and therefore, can be widely applied to various uses in interior field, clothing field and the like, such as automobile, upholstery in automobile, decoration purposes, toy, furniture, footwear, bag, shoes, bag, belt, gloves, binding and the like. In addition, the flame-
20 retardant polyester fiber of the present invention can be used for clothing such as clothes, night clothes and the like, interior products such as curtain, blind, wallpaper and the like, industrial materials such as safety net, aging sheet, mesh sheet for construction, sheet for construction and the like, bed
25 clothes such as fabric, cotton pad and the like, products for fire prevention such as blanket, tent, sheet, curtain, hood for fire prevention, cover of chair, automobile body cover and the like, office products such as partition cloth, artificial tree and the like, domestic electrical goods such as grille cloth for
30 speakers and the like, railroad car supplies such as fabric for seat, curtain, screen and the like, automobile equipment such as fabric for seat, curtain and the like, blanket, filter for air conditioning and the like for seacraft and airplane, and the like, and is industrially extremely valuable.

Table 1

polymer	phosphorus compound	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.6	Ex.7	Ex.8	Comp. Ex.1	Comp. Ex.2	Comp. Ex.3	Comp. Ex.4	Comp. Ex.5	Comp. Ex.6
		side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	side chain type	main chain type
spinning conditions	phosphorus atom content (ppm)	6000	6000	6000	3500	6000	6000	6000	6000	300	60000	6000	6000	6000	6000
	intrinsic viscosity	0.605	0.605	0.605	0.605	0.605	0.605	0.605	0.605	0.610	0.560	0.605	0.605	0.605	0.605
	spinning temperature (°C)	262	262	262	265	262	262	262	262	269	260	262	262	262	262
	shear rate (s ⁻¹)	6010	4307	3676	6010	7067	4369	6010	8417	6010	6010	6010	2161	12603	6010
drawing conditions	cooling start distance (mm)	65	35	65	65	65	65	65	25	65	65	120	65	65	65
	take-up speed (m/min)	1450	1300	3000	1450	1450	1450	1450	2450	1450	1450	1450	1450	1450	1450
	preheating temperature (°C)	80	80	100	80	80	80	80	85	80	80	80	80	80	80
	setting temperature (°C)	160	160	160	160	160	160	145	150	160	160	160	160	160	160
properties of original fiber	draw ratio	2.79	2.88	1.67	2.79	3.40	2.10	2.79	1.63	2.79	2.59	2.92	2.92	-	2.79
	fineness (dtex)	167	56	84	167	167	167	167	100	167	167	167	167	-	167
	number of filaments	48	24	24	48	48	48	48	216	48	48	48	48	-	48
	tanmax	0.259	0.258	0.258	0.253	0.253	0.258	0.266	0.236	0.200	0.291	0.237	0.231	-	0.230
strength at break	T ₅₀ (°C)	129.0	128.8	128.1	130.8	129.8	127.4	128.2	122.1	133.9	124.9	132.3	130.2	-	133.9
	An	0.120	0.108	0.099	0.121	0.132	0.110	0.101	0.118	0.146	0.074	0.134	0.138	-	0.152
	SG (g/cm ³)	1.3770	1.3772	1.3699	1.3788	1.3802	1.3769	1.3687	1.3718	1.3745	1.3778	1.3780	1.3780	-	1.3755
	SG-√An/8.64	1.337	1.339	1.333	1.339	1.338	1.339	1.332	1.332	1.330	1.346	1.336	1.335	-	1.330
elongation at break	strength at break (CN/dtex)	4.15	4.29	3.82	4.25	4.46	3.34	4.11	4.05	4.35	3.55	4.18	4.22	-	4.22
	break;DE (%)	32.3	32.7	34.2	32.8	12.6	64.1	32.5	34.7	31.9	33.0	33.5	34.0	-	34.3
	SW (%)	8.5	8.6	9.3	8.2	10.2	7.8	12.3	6.9	7.9	11.1	9.3	9.3	-	9.1
	LOI	29.0	29.1	29.2	27.8	28.9	29.0	29.1	29.0	23.4	34.2	28.9	29.2	-	29.2
abrasion resistance (times)	abrasion resistance	8730	8239	8188	10147	6120	8844	8545	7720	13290	5834	8765	6403	-	6403
	La value	15.3	15.2	15.1	15.4	15.3	15.2	15.2	15.3	16.5	14.8	15.2	15.4	-	16.1
	color fastness to light (grade)	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4	5	3-4	4-5	4-5	-	4-5
	Note			spin-draw method		occurrence of nap during knitting	dimensional change during knitting	dimensional low stability	spin-method		frequent cutting of fiber			spinning not possible	

Table 2

	phosphorus compound		amount of polymerization catalyst (ppm)				fluorescent brightener	polymer property			flame retardancy	hydrolysis resistance
	kind	amount (ppm)	G	S	C	S+2G+C		IV (dl/g)	L	b		
Ex. 10	(x)	3500	75	188	30	368	-	0.65	71.1	3.59	27	0.3
Ex. 11	(x)	3500	75	150	15	355	220	0.64	73.9	-0.75	27	0.33
Ex. 12	(x)	6000	75	188	30	365	220	0.61	70.8	0.5	28	0.35
Ex. 13	(y)	6000	75	150	-	300	220	0.63	73.3	-0.52	28	0.43

WHAT IS CLAIMED IS

1. A flame-retardant polyester fiber comprising a phosphorus compound copolymerized polyester satisfying the following formulas (1)-(3) and having a phosphorus atom content of 500-50,000 ppm:

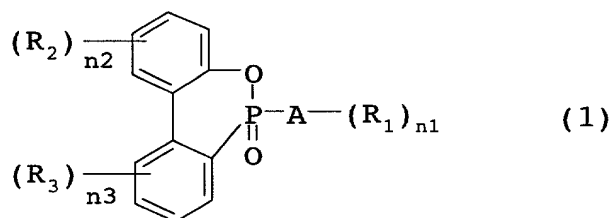
$$\tan \delta_{\max} \geq 0.1740 \quad (\text{formula 1})$$

$$T\alpha - 3.77 \times \ln (\text{dtpf}) \leq 137.0 \quad (\text{formula 2})$$

$$1.331 \leq SG - \frac{\sqrt{\Delta n}}{8.64} \leq 1.345 \quad (\text{formula 3})$$

wherein $\tan \delta_{\max}$ is a maximum value of loss tangent in a dynamic viscoelasticity measurement, $T\alpha$ is a temperature at which loss tangent reaches the maximum, dtpf is single fiber fineness (dtex), SG is density (g/cm^3), and Δn is birefringence.

2. The flame-retardant polyester fiber of claim 1, which comprises a copolymerized polyester obtained by adding a phosphorus compound of the following formula (1):



- wherein R_1 is a monovalent ester-forming functional group, R_2 and R_3 are the same or different and each is selected from a halogen atom, a hydrocarbon group having 1 to 10 carbon atoms and R_1 , A is a divalent or trivalent organic residue, n_1 is 1 or 2 and n_2 and n_3 are each an integer of 0 to 4.

3. The flame-retardant polyester fiber of claim 1, which is characterized by not less than 6500 times up to an occurrence of cutting by abrasion under a load of 0.098 N/tex in a yarn abrasion test.

4. The flame-retardant polyester fiber of claim 1, which shows a tensile elongation at break (DE) of 20-50%.

5 5. The flame-retardant polyester fiber of claim 1, which shows a shrinkage in hot water (SHW) of not more than 10%.

6. The flame-retardant polyester fiber of claim 1, which satisfies the following formula 4, wherein a L value is not less
10 than 67 and a b value is not more than 10.00 as measured with a Hunter's color-difference meter:

$$\%B.B. < 0.5 \quad (\text{formula 4})$$

wherein %B.B. is a proportion of ester bond broken upon immersion in a closed system in pure water at 130°C for 6 h,
15 which can be determined by the following formula (5) wherein an intrinsic viscosity before immersion is $[\eta]_i$ and that after immersion is $[\eta]_f$, and the intrinsic viscosity is determined in a mixed solvent of phenol/1,1,2,2-tetrachloroethane (weight ratio 3/2) at 30°C:

20

$$\%B.B. = 0.244 \times \{[\eta]_f^{-1.471} - [\eta]_i^{-1.471}\} \quad (\text{formula 5}).$$

7. The flame-retardant polyester fiber of claim 1, wherein the phosphorus compound copolymerized polyester comprises an organic
25 fluorescent brightener in a proportion of 0.01-1 wt% and, as a condensation polymerization catalyst, an antimony compound, a germanium compound and a cobalt compound in amounts that simultaneously satisfy the following formulas (6)-(9):

$$30 \leq S \leq 400 \quad (\text{formula 6})$$

30 $10 \leq G \leq 100 \quad (\text{formula 7})$

$$5 \leq C \leq 40 \quad (\text{formula 8})$$

$$200 \leq S+2G+C \leq 400 \quad (\text{formula 9})$$

wherein S, G and C are each a content (ppm) of an antimony atom, germanium atom or cobalt atom relative to the polyester.

35

8. A flame-retardant polyester woven, knitted fabric comprising the flame-retardant polyester fiber of claim 1 at least in a part thereof.

5

9. A suede raised woven, knitted fabric, which is a raised woven, knitted fabric comprising the flame-retardant polyester woven, knitted fabric of claim 8 that underwent a raising treatment, and which shows a coefficient of friction of a surface of the
10 woven, knitted fabric by a surface tester KES-FB4 of 0.200-0.300.

10. A flame-retardant polyester raised warp knitted fabric, which is a raised woven, knitted fabric comprising the flame-retardant polyester woven, knitted fabric of claim 8 that
15 underwent a raising treatment, and which shows an after-flame time of not more than 3 sec as measured by the following test method:

20 a flame of a lighter is drawn up to a bottom end of a specimen (1.5 cm x 20 cm) stood vertically and the flame is drawn back when the specimen is inflamed, along with which the after-flame time of the specimen is measured.

11. A flame-retardant polyester nonwoven fabric comprising the flame-retardant polyester fiber of claim 1 at least in a part
25 thereof.

**COMBINED DECLARATION AND POWER OF ATTORNEY
FOR UTILITY PATENT APPLICATION**

AS A BELOW-NAMED INVENTOR, I HEREBY DECLARE THAT:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

FLAME-RETARDANT POLYESTER FIBER, WOVEN OR KNITTED FLAME-RETARDANT
POLYESTER FIBER FABRIC, NONWOVEN FLAME-RETARDANT POLYESTER FIBER
FABRIC AND WOVEN OR KNITTED SUEDE FABRIC

, the specification of which is attached hereto unless the following box is checked:

☒ was filed on July 18, 2001 as United States Application Serial No. 09/889,508
or PCT International Application No. and was amended on
(if applicable).

I HEREBY STATE THAT I HAVE REVIEWED AND UNDERSTAND THE
CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS,
AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE.

I acknowledge the duty to disclose information which is material to the patentability as
defined in 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any
foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International
application which designated at least one country other than the United States listed below and
have also identified below, by checking the box, any foreign application for patent or inventor's
certificate, or PCT International application having a filing date before that of the application on
which priority is claimed:

Application No.	Country	Date of Filing (day/month/year)	Priority Claimed?
10089/1999	Japan	19/01/1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Application No.	Country	Date of Filing (day/month/year)	Priority Claimed?
345124/1999	Japan	03/12/1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Application No.	Country	Date of Filing (day/month/year)	Priority Claimed?
353589/1999	Japan	13/12/1999	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
Application No.	Country	Date of Filing (day/month/year)	Priority Claimed?
			<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

Application Serial No.	Filing Date

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.	Filing Date	Status
		<input type="checkbox"/> Patented <input type="checkbox"/> Pending <input type="checkbox"/> Abandoned

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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